

# WASTEWATER NITROGEN & PHOSPHORUS REMOVAL WITHOUT PLANT UPGRADES: OPTIMIZING THE OPERATION OF EXISTING FACILITIES

GRANT WEAVER, PE & WASTEWATER OPERATOR

US ENVIRONMENTAL PROTECTION AGENCY – REGION 8  
DECEMBER 10, 2013



## *Traditional Approach: Facility Planning*



your design solution  
{ web video print app }

*As an analogy, let's assume ...*

*I have a five year old car that squeaks and sputters.  
I'm looking for advice.*



*As an analogy, let's assume ...*

*I have a five year old car that squeaks and sputters.  
I'm looking for advice.*



*Alternative Approach: Use Existing Equipment Differently to Create Habitats to Support N&P Removal*



## *Montana DES*

### Two Day Classroom Seminar (2012)

	<u>t-N Before (mg/L)</u>	<u>t-N After (mg/L)</u>
Chinook	25	13
Conrad	26	5
Manhattan	11	7



## Facilities Not Designed for Nitrogen Removal

	<u>t-N Before</u>	<u>t-N After</u>
Montague, MA	11	5
Upton, MA	20	6
Palmer, MA*	20	8
Plainfield Village, CT	20	8
Plainfield North, CT	15	8
Farmington, CT	12	8
Amherst, MA	25	10

## Facilities Operated Differently from O&M Manual

	<u>t-N Before</u>	<u>t-N After</u>
Suffield, CT	6	2
Windsor Locks, CT	7	5
Colchester-East Hampton, CT	11	8





## *Phosphorus Removal without Facility Upgrades*

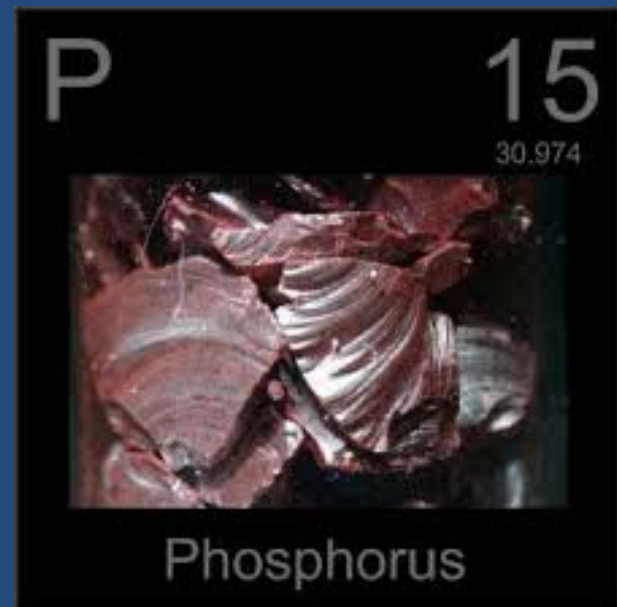
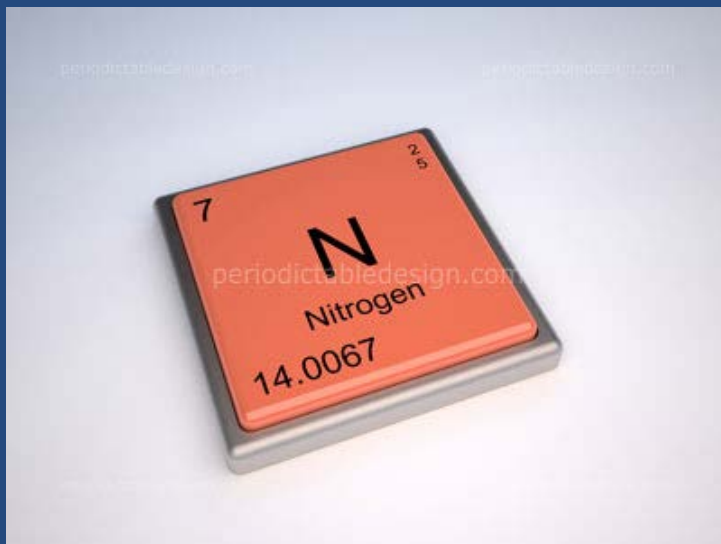


	<u>t-P Before</u>	<u>t-P After</u>
Keene, NH	3.0	0.2
East Haddam, CT	3.5	0.4
Montague, MA	5.5	0.6
Suffield, CT	3.0	0.7
Plainfield Village, CT	3.0	0.8





# *Nutrient Removal*



*Biological Nitrogen Removal:  
Soluble organic-N is converted to Nitrogen Gas*

**Oxygen Rich Habitat**

Ammonia-Nitrogen ( $\text{NH}_4$ ) converts to Nitrate-Nitrogen ( $\text{NO}_3$ )

**Oxygen Poor Habitat**

Nitrate-Nitrogen ( $\text{NO}_3$ ) converts to Nitrogen Gas ( $\text{N}_2$ )



0010340



*Biological Phosphorus Removal:  
Soluble ortho-P is removed as sludge (dead bacteria)*

### Zero Oxygen Habitat

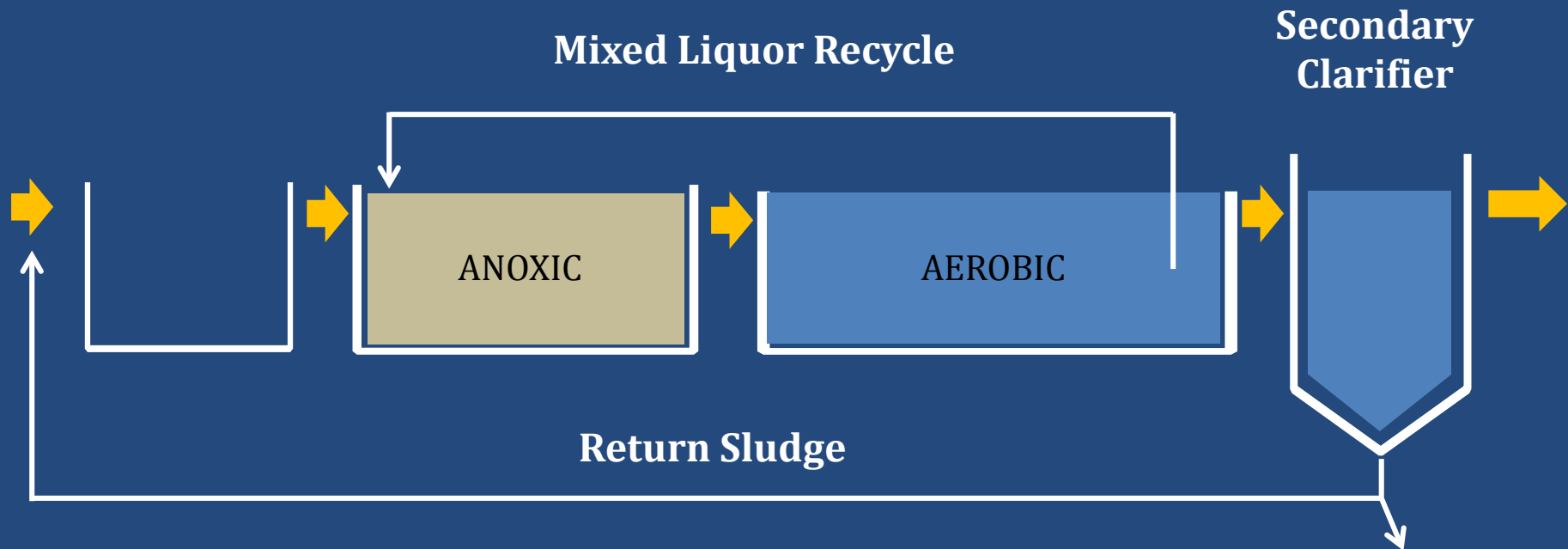
Bacteria take in energy (VFAs) and temporarily expel P

### Oxygen Rich Habitat

Bacteria use energy to “bulk up” on ortho-P

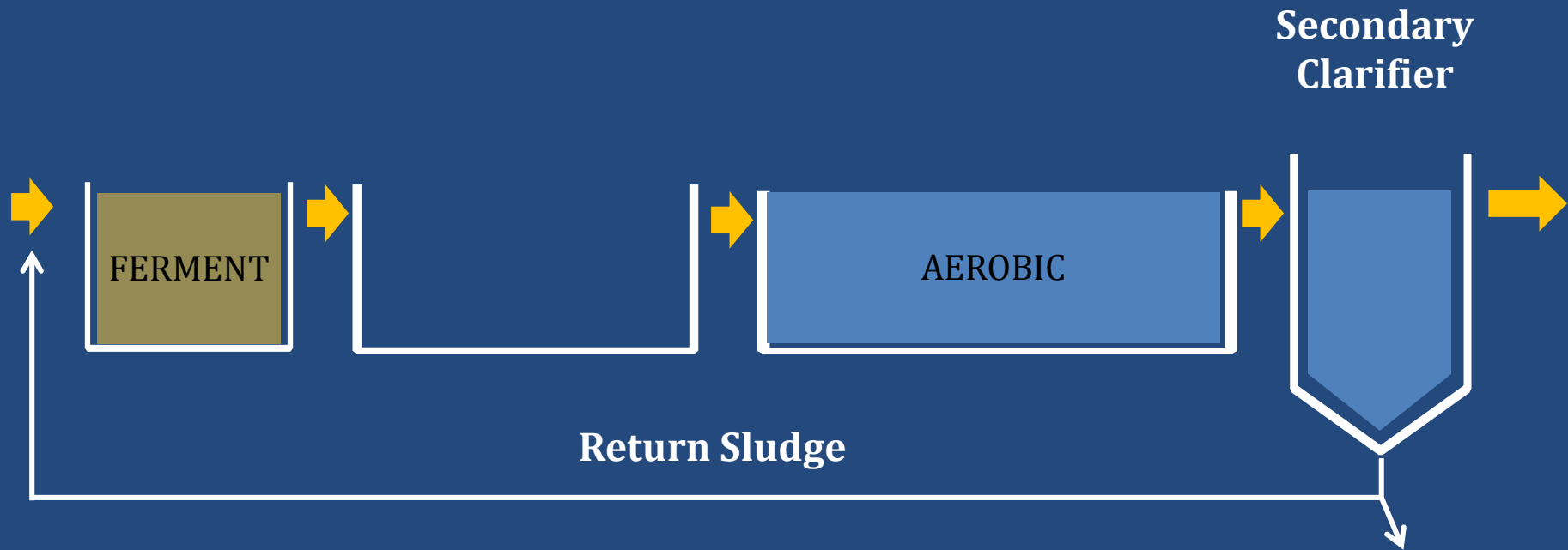


0010341



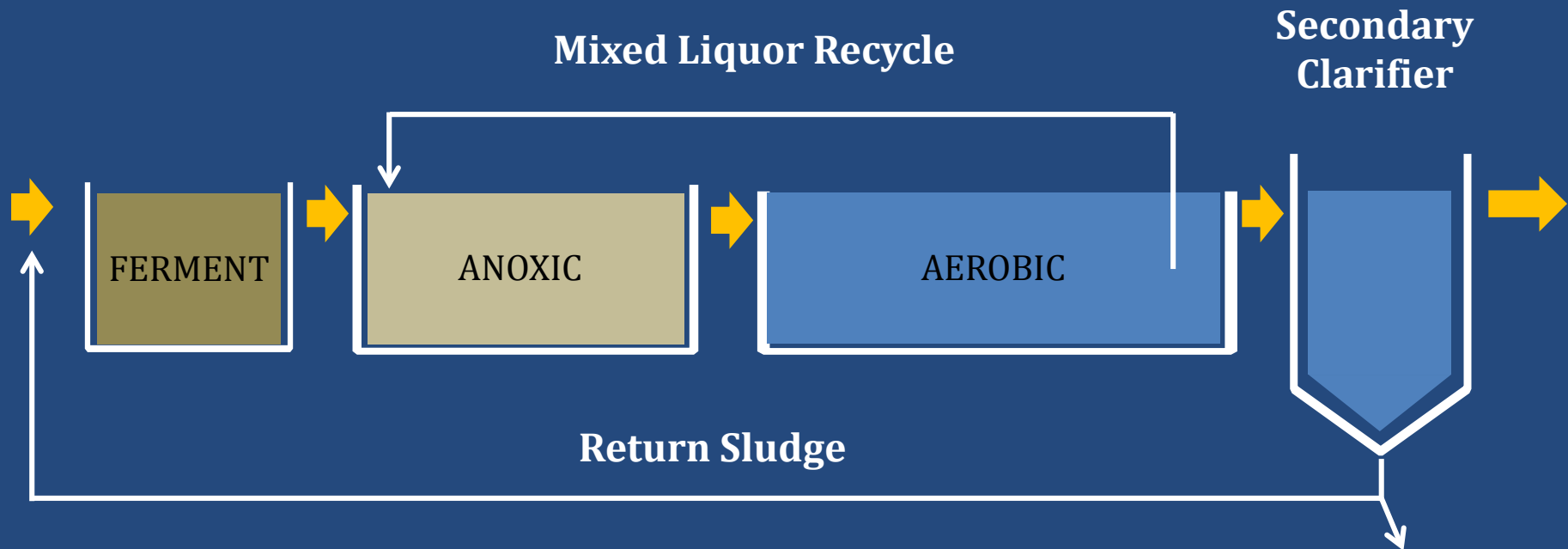
## Biological N&P Removal Nitrogen





## Biological N&P Removal Phosphorus

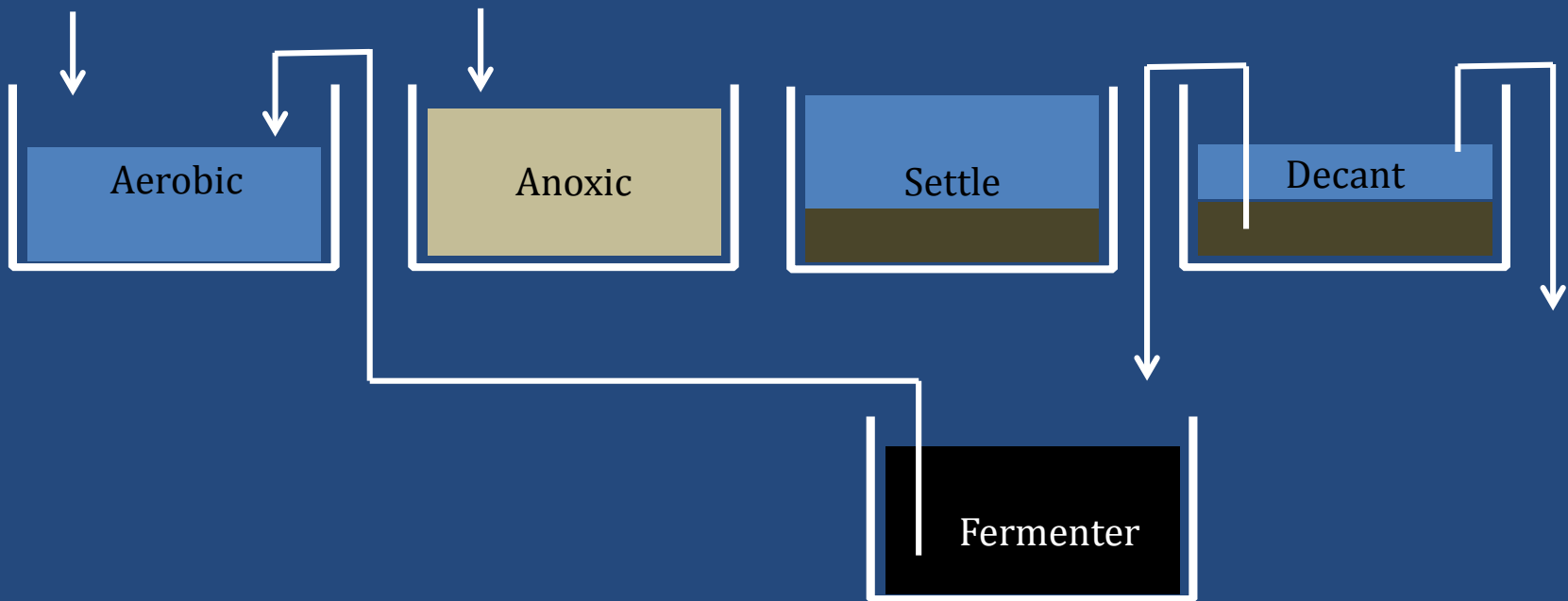




## Biological N&P Removal



## Biological N&P Removal: SBR w/Fermenter





# THE SCIENTIFIC METHOD

? **PURPOSE** ?  
WHAT DO I WANT TO LEARN?

**Research**

Find out as much about your topic as you can.



**HYPOTHESIS**

Predict what the answer to the problem is.

**EXPERIMENT**

Design a test to confirm or disprove your hypothesis.



**Analysis**



Record what happened during the experiment.



**Conclusion**

Was my hypothesis correct?

# *NextGen Treatment Requires NextGen Operations: More Wastewater Operator Attention is Required!*



## Knowledge

Nitrogen biochemistry

Phosphorus biochemistry

## Information (*in-line instrumentation & SCADA*)

Continuously monitor conditions

Interpret data daily

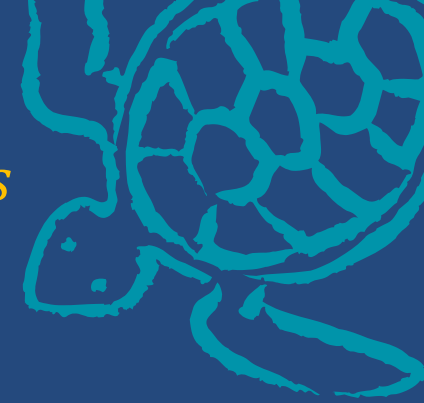
## Action

Daily adjustments

Preemptive changes

Reactive changes





## Case Study: \$100 Million Savings @ 3 Communities



60% Nitrogen Reduction

80% Phosphorus Reduction

Existing equipment: No New Tanks

O&M cost SAVINGS

Fewer Chemicals

Less Electricity

Less Sludge

Carbon Footprint: REDUCED



## *Case Studies: \$100 million savings*

Combined Population: 76,000

Total Design Capacity: 14.7 MGD

	<u>total-N (mg/L)</u>	<u>total-P (mg/L)</u>
Amherst, MA	25 to 10	
Keene, NH		3.0 to 0.2
Plainfield (CT) North	15 to 8	
Plainfield (CT) Village	20 to 8	3.0 to 0.8

## *Plainfield, Connecticut*

Population: 15,000

Two Plants

North Design Flow: 1.5 MGD

Village Design Flow: 0.6 MGD

No new effluent limits, but monetary advantage to reducing nitrogen





## *Plainfield, Connecticut North Plant*

Design Flow: 1.0 MGD

Actual: 0.4 MGD

### Effluent total-N

Before Changes: 15 mg/L

After Operational Changes: 8 mg/L

After Plant Renovation: 5 mg/L (anticipated)

### Effluent total-P

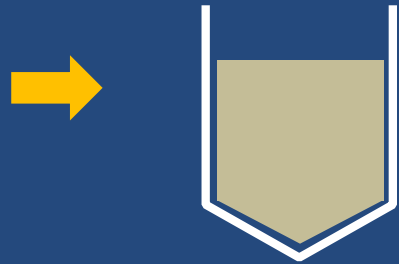
Before Changes: 2.0 mg/L

After Operational Changes: 2.0 mg/L

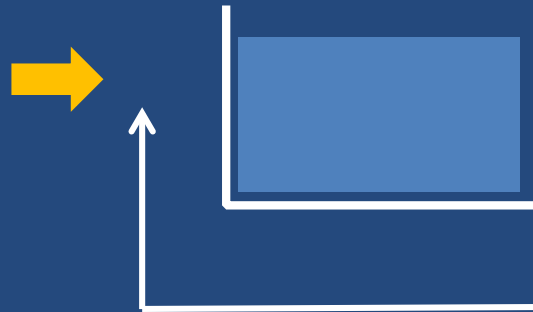
After Plant Renovation: 1.0 mg/L (anticipated)



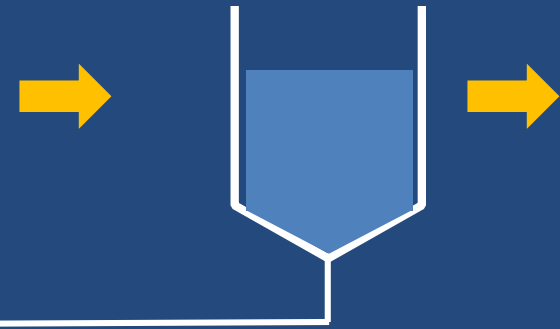
Primary  
Clarifier



Aeration  
Tank



Secondary  
Clarifier



*North Plant  
Plainfield, Connecticut*

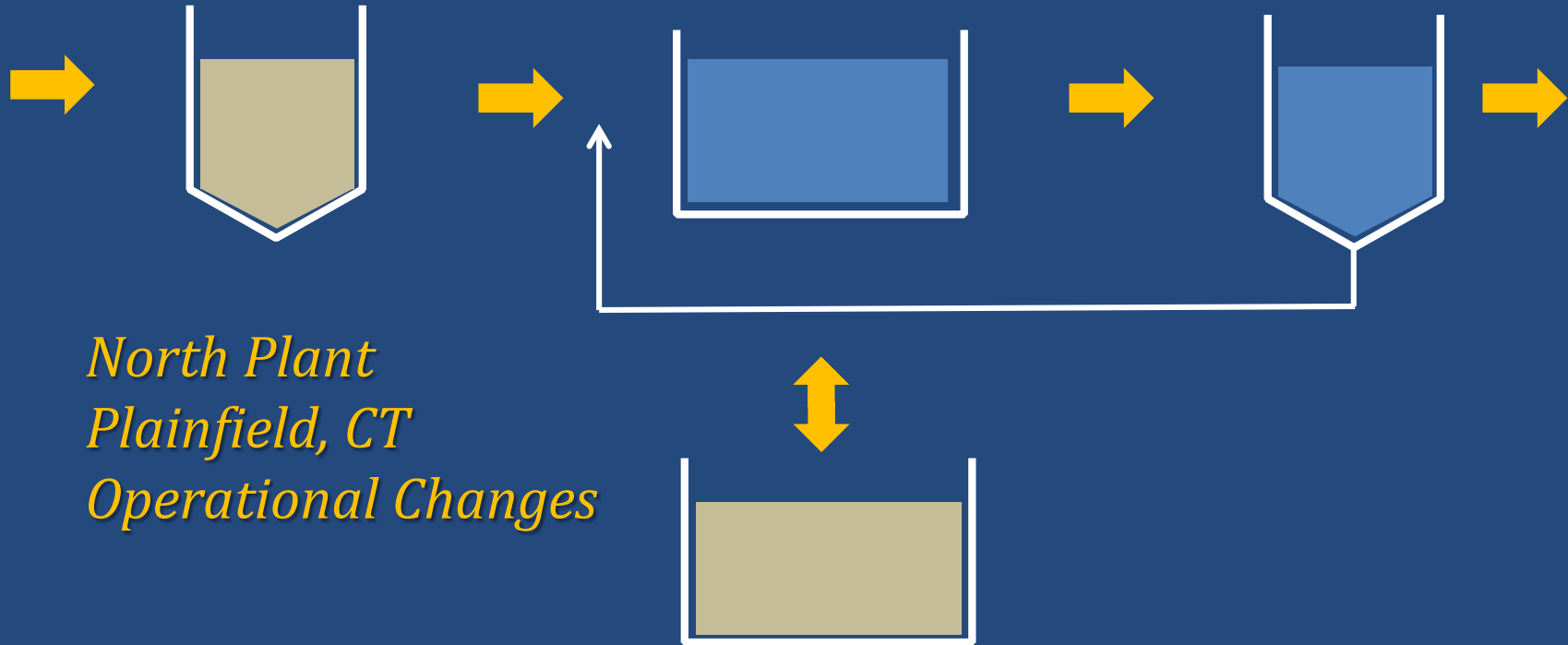




Primary  
Clarifier

Aeration  
Tank

Secondary  
Clarifier



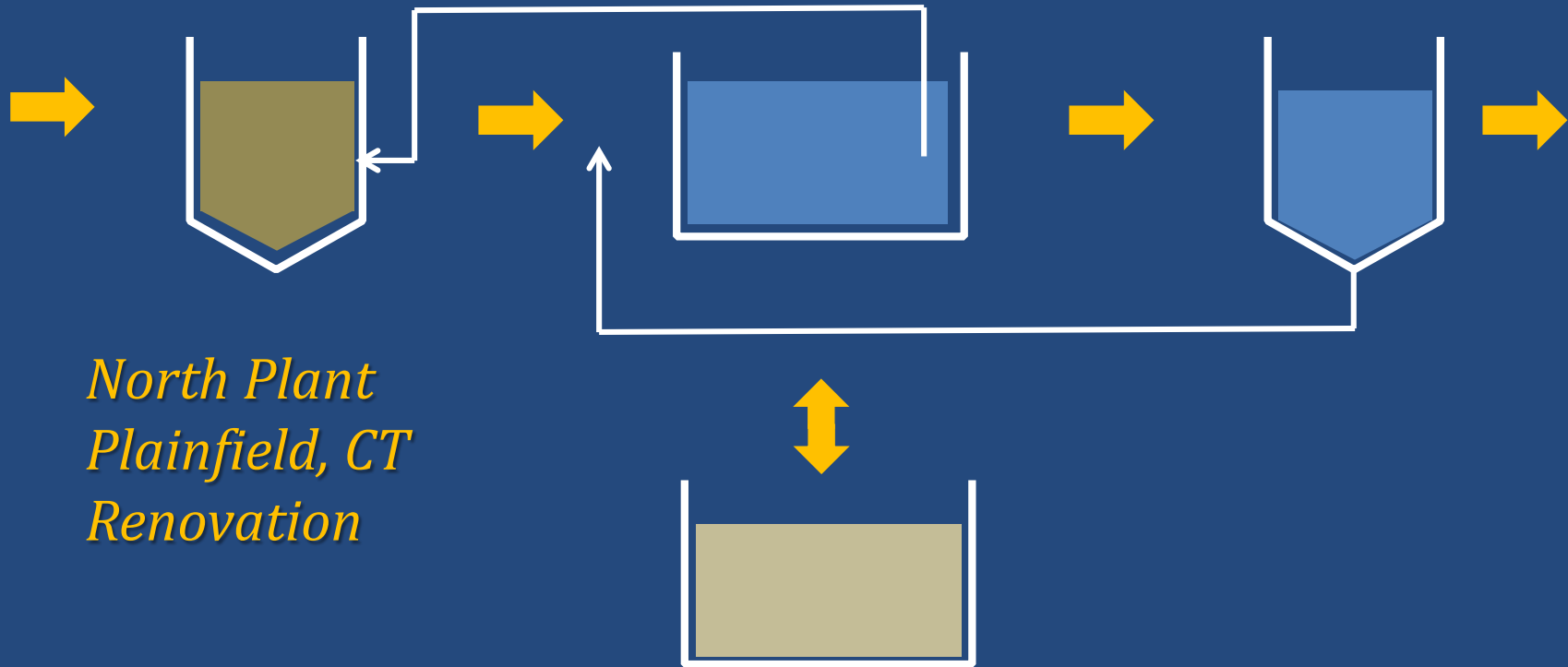
*North Plant  
Plainfield, CT  
Operational Changes*



Primary  
Clarifier

Aeration  
Tank

Secondary  
Clarifier



*North Plant  
Plainfield, CT  
Renovation*



# *Case Study*

## *Plainfield, Connecticut*

### *Village Plant*

Design Flow: 0.5 MGD

Actual: 0.2 MGD

Effluent total-N

Before Changes: 20 mg/L

After Operational Changes: 8 mg/L

After Renovation (anticipated): 5 mg/L

Effluent total-P

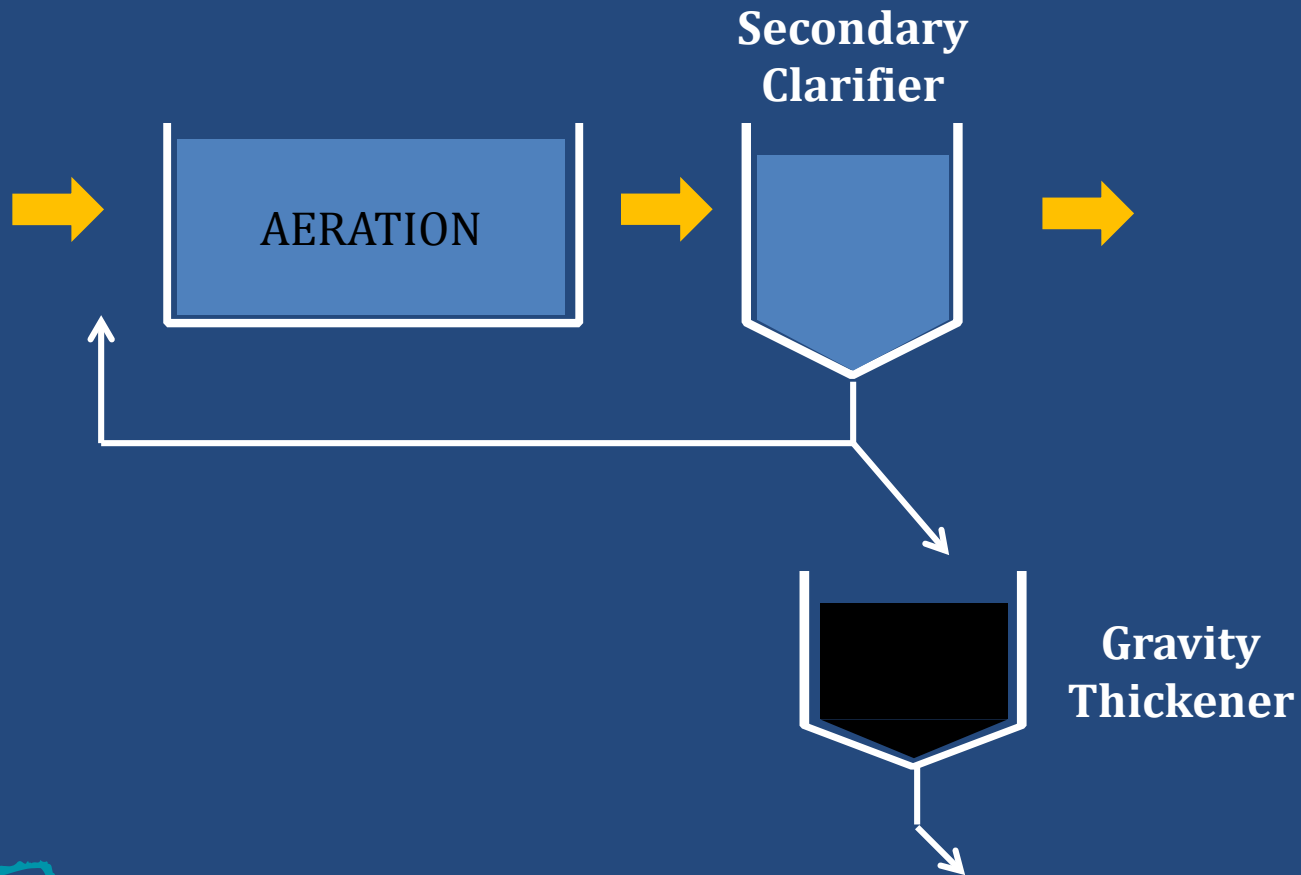
Before Changes: 3 mg/L

After Operational Changes: 0.8 mg/L

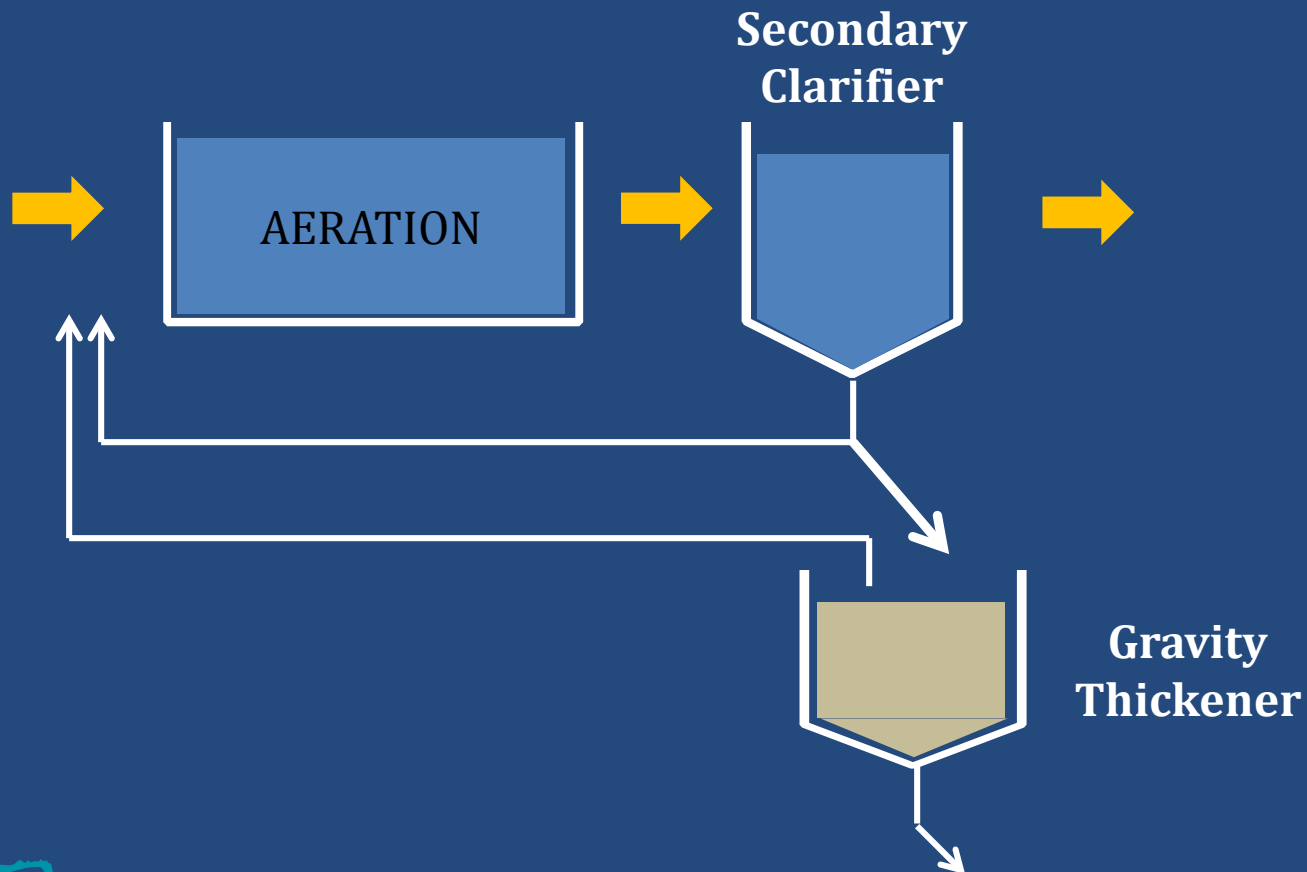
After Renovation (anticipated): 0.5 mg/L



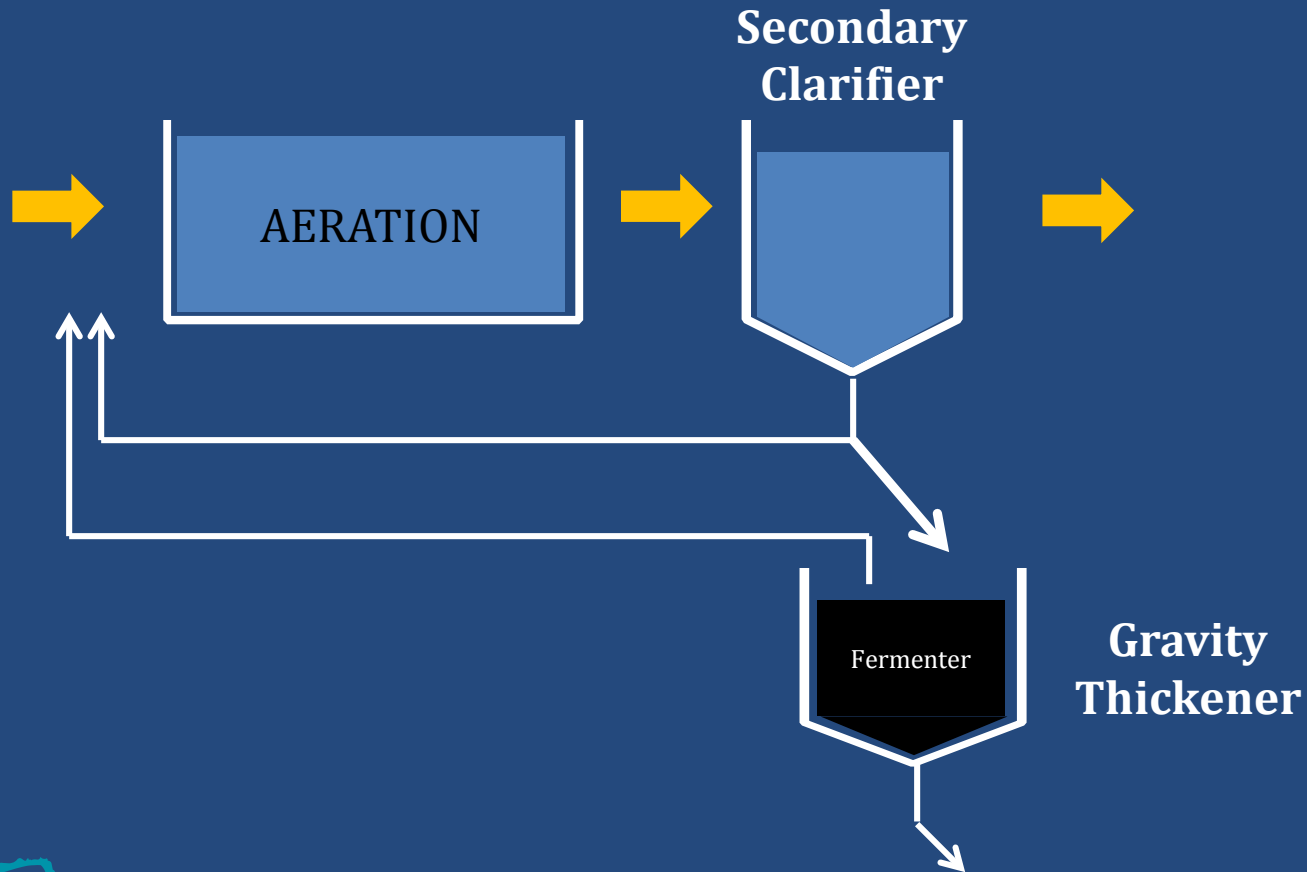
## *Plainfield Village*



*Plainfield Village*  
*Gravity Thickener as Post-Anoxic tank for bio-N removal*



*Plainfield Village*  
*Gravity Thickener as Fermenter for bio-P removal*



## *Plainfield, Connecticut*

New Facility Upgrade: **\$5,000,000**

Renovate both treatment plants

Original Facility Upgrade: **\$45,000,000**

Replace Village Plant with Pumping Station

Build all new plant at site of existing North Plant





## *Case Study*

### *Amherst, Massachusetts*

Population: 38,000

Design Flow: 7.2 MGD

Actual: 5.0 MGD (school in session)  
3.5 MGD (school break)

Effluent total-N

Before: 25 mg/L

After: 10 mg/L

With pH buffering: 6 mg/L (anticipated)

Effluent total-P

Before and After: 3 mg/L



## *Amherst, Massachusetts*

New Nitrogen Limit: 546.5 pounds/day, approximately 13 mg/L

2008 BioWin modeling found facility “not capable of removing nitrogen.”

Facility Upgrade cost estimate: \$61,000,000

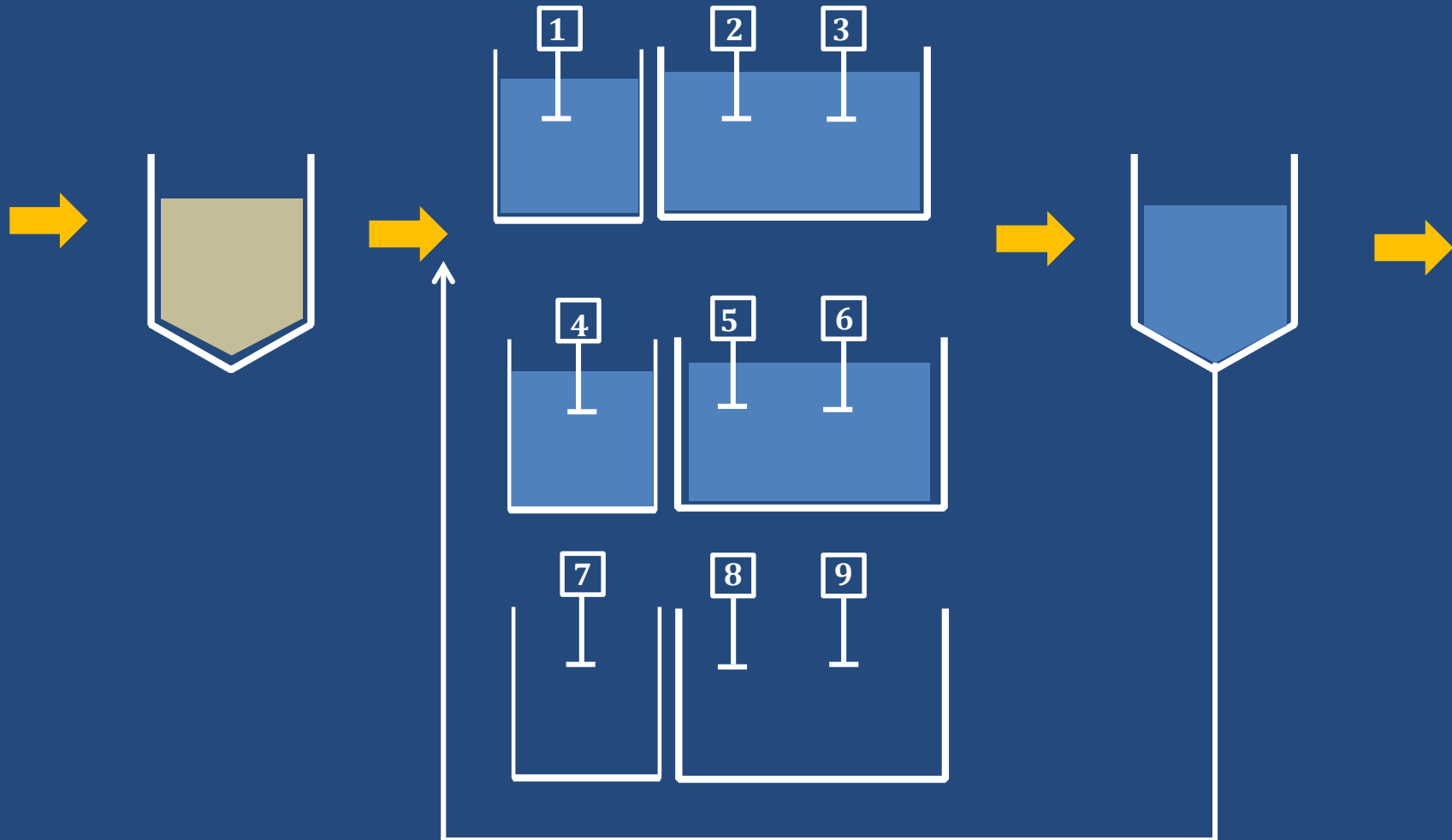


0010361

## Primary Clarifiers

## Aeration Tanks

## Secondary Clarifiers



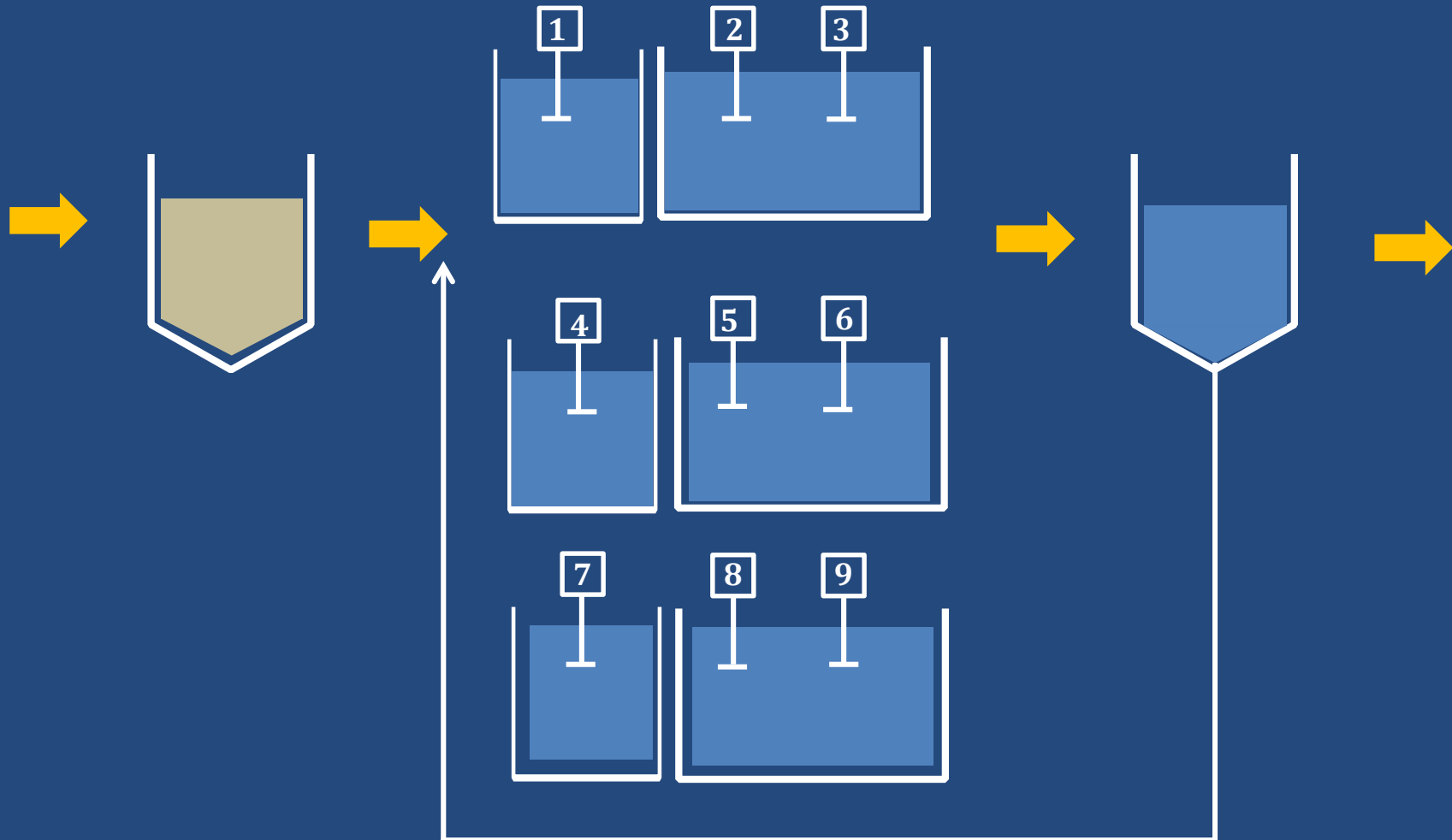
Amherst, Massachusetts

0010362

## Primary Clarifiers

## Aeration Tanks

## Secondary Clarifiers



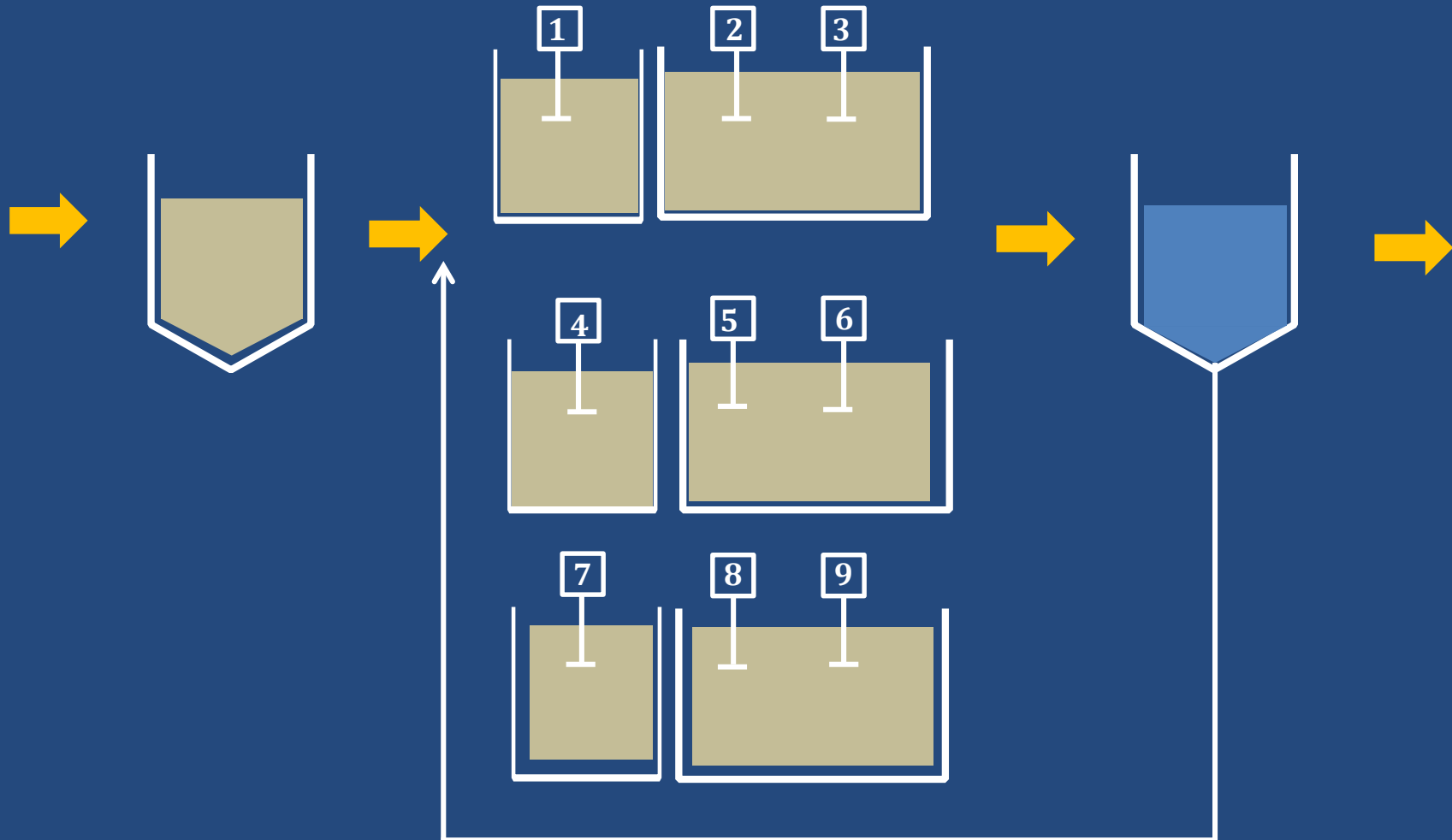
Amherst, Massachusetts

0010363

## Primary Clarifiers

## Aeration Tanks

## Secondary Clarifiers



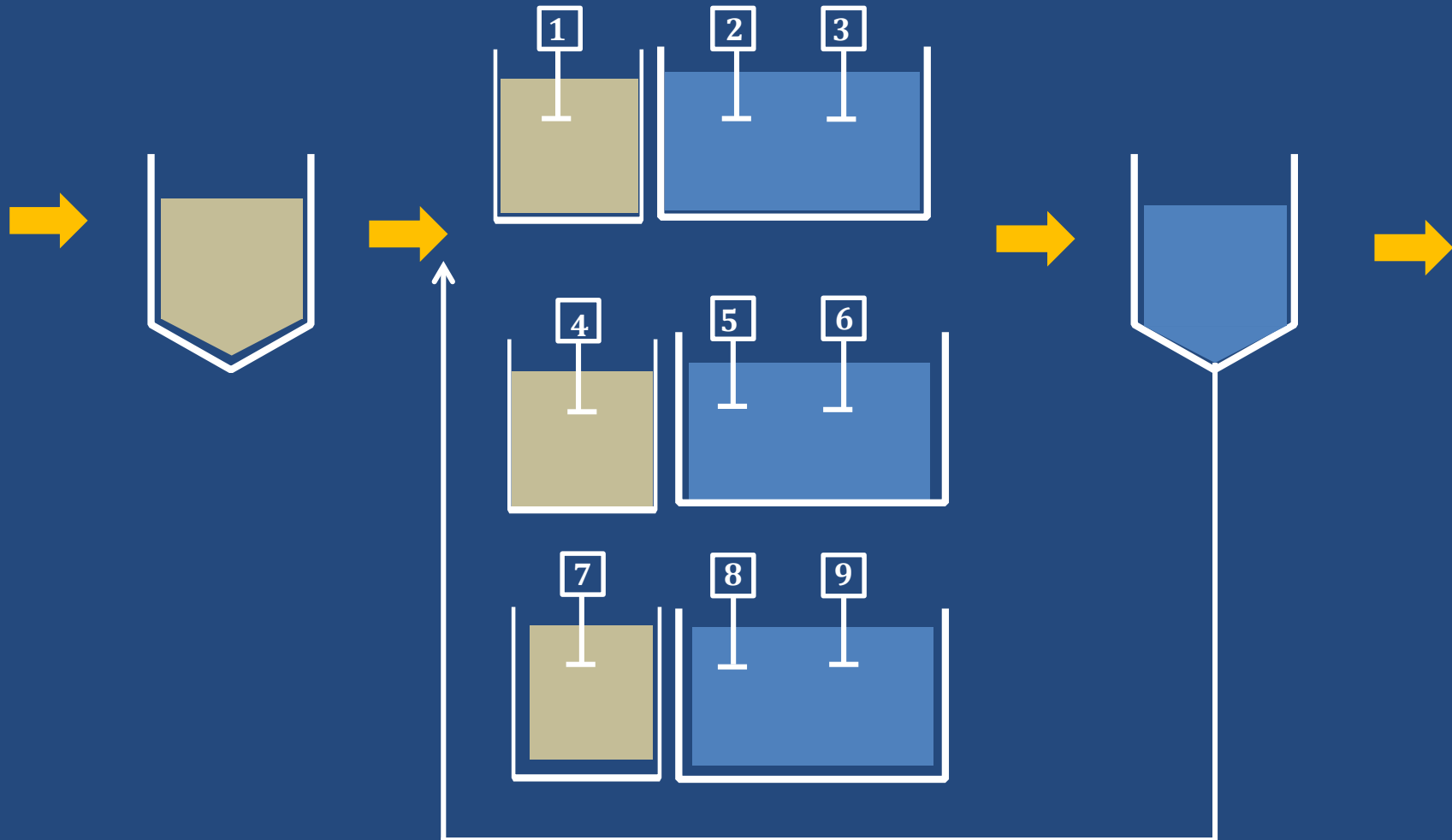
Amherst, Massachusetts

0010364

## Primary Clarifiers

## Aeration Tanks

## Secondary Clarifiers



Amherst, Massachusetts

0010365

## *Amherst, Massachusetts*

Cost of Compliance: **< \$100,000**

Proposed Facility Upgrade: **\$61,000,000**

2008 BioWin modeling results:

*... “there are no operational or minor modifications/retrofits that could be implemented at this facility to consistently achieve nitrogen removal.*

*The existing facility has half of the necessary volume at the current flows ...”*





## *Case Study*

### *Keene, New Hampshire*

Population: 23,000

Design Flow: 6.0 MGD

Actual: 3.0 MGD

Effluent total-N

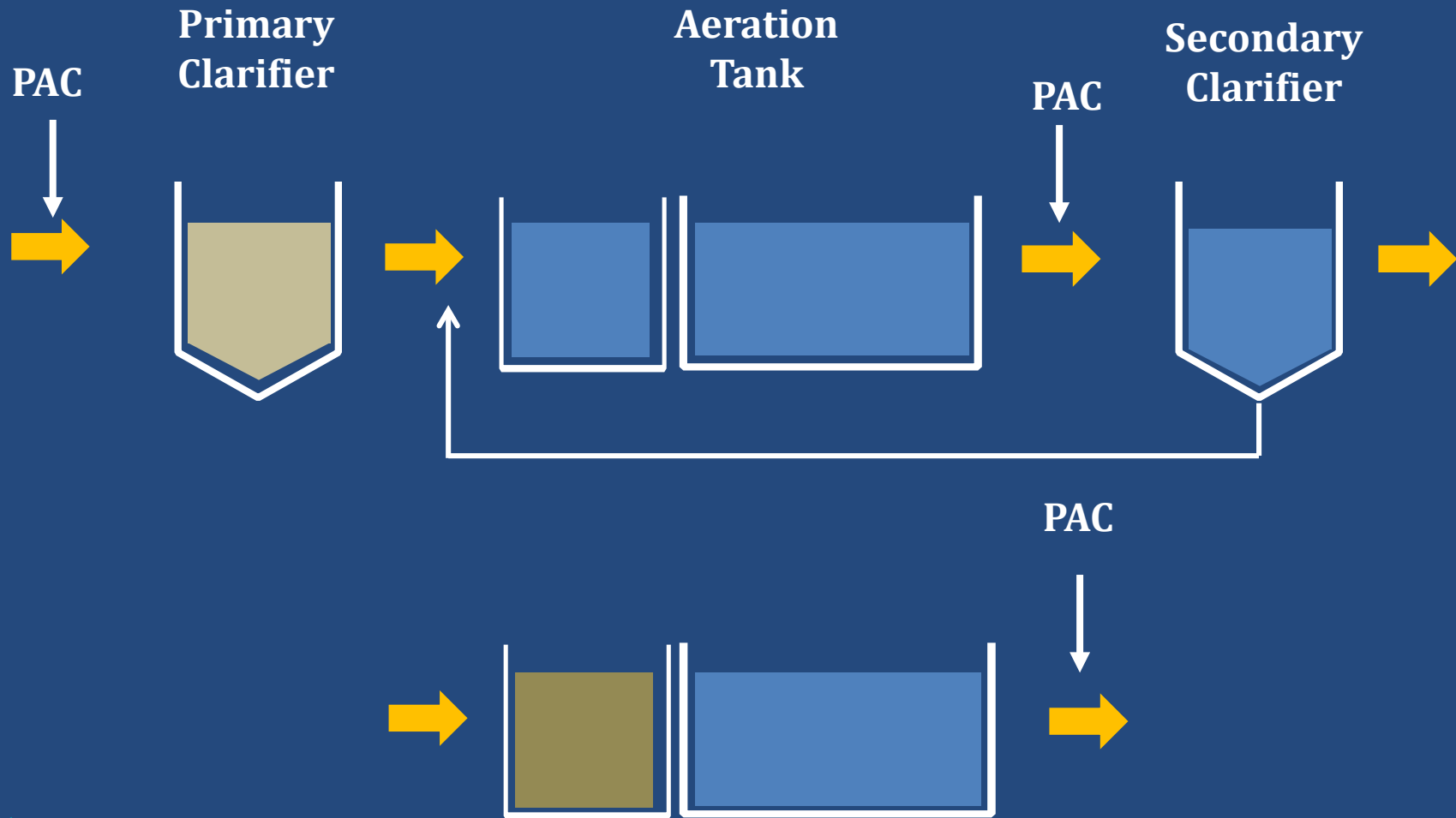
Before & After: 8 mg/L

Effluent total-P

Before Changes: 3.0 mg/L

After Changes: 0.2 mg/L





*Keene, New Hampshire*

## *Keene, New Hampshire*

Modified Plant Upgrade: **\$4,000,000**

Proposed Facility Upgrade: **\$12,000,000**





## *Case Studies*

### **Improved Treatment**

Nitrogen Removal

Phosphorus Removal

Before (mg/L)

15-25

3.0

After (mg/L)

6-10

0.2-0.8

### **O&M Costs**

Amherst, MA

\$30,000/yr Savings (sludge disposal)

Plainfield, CT

Small Savings

Keene, NH

\$50,000/yr Savings (chemical usage)



## *Findings*

Wastewater treatment plants can remove Nitrogen &/or Phosphorus at fantastic savings: \$ Billions

Instrumentation and computer controls are cost-effective; but, rarely purchased:

Local funds (O&M budgets) are tight

Clean Water Funds not practical

Operator expertise required



## *Ideas for EPA to consider ...*

Promote Optimization

Train & Empower Operators

Make Money Readily Available for \$500K Projects

Instrumentation and Computer Control  
Installation

Remote interpretation and on-going Support

“Innovative and Alternative” Funding for Regional Optimization Effort(s):  
State(s)  
Watershed(s)

“Means Test” Process Changes before Capital Improvement Funding





Making clean water affordable

[GrantWeaver@theWaterPlanetCompany.com](mailto:GrantWeaver@theWaterPlanetCompany.com)

0010373



Thank You!

GrantWeaver@theWaterPlanetCompany.com





# *Grant Weaver, Your Presenter*

President  
The Water Planet Company  
Wastewater Operations & Maintenance  
Wastewater Consulting

Licensing  
Professional Engineer (CT and PA)  
Wastewater Operator (CT, MA, NH, RI)

Education  
Kansas State University: BS Biology  
Oklahoma State University: MS Bio-Environmental Engineering  
Massachusetts Institute of Technology: Post-Graduate Studies in  
Environmental Toxicology

